Urban Challenge

Site Visit Guidelines

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Table of Contents

Revision Summary

Date	Section	Description
1/16/07	5.1 Course Configuration	Revised 2nd bullet to read "lane width = 4.5 meters"
2/26/07	3 Location and Schedule/Table 1	Included the requirement for a digital photograph of the Site Visit location. Revised the submission schedule: "Site Visit information" date was changed from March 2, 2007 to March 16, 2007. "Site Visit information reviews complete DARPA sends notifications" date was changed from March 30, 2007 to April 13, 2007.
2/26/07	Appendix: Site Visit Checklist	Site Visit Checklist dates changed: *Preliminaries* • Email Site Visit Information Sheet to DARPA, including digital photo(s) of site (March 16) • Email Site Visit RNDF to DARPA (March 16) Receive feedback from DARPA regarding RNDF (April 13)
3/8/07	3 Location and Schedule	Site visit selection announcement date changed from May 11 to May 10, 2007.
3/8/07	5.1 Course Configuration	Revised 2nd bullet to read "lane width less than or equal to 4.5 meters"
3/8/07	Appendix: Site Visit Checklist	Site Visit Checklist changed: *Course* • Lane width less than or equal to 4.5 meters
3/19/07	4.3 Sequence of Events	Step 4. Wording changed from "pause and run operation" to "pause, disable, and run operation".
4/24/07	4.3 Course Marking	Figure 5 depicting course markings is revised.
6/18/07	4.3 Sequence of Events	Filming restrictions clarified

Urban Challenge

Site Visit Guidelines

1. Introduction

The Urban Challenge Site Visit is part of the qualification process for the DARPA Urban Challenge. The Site Visit and Technical Paper are used by DARPA to determine the teams invited to the National Qualification Event (NQE) as Urban Challenge semifinalists. This document provides teams with instructions and guidelines for planning and conducting a successful Site Visit.

At the Site Visit, DARPA officials verify conformance with the vehicle requirements set forth in the Urban Challenge Rules and observe tests of basic navigation and basic traffic behaviors to assess vehicle capability and system maturity. Vehicle requirements and behavior criteria are outlined in the "Rules" and the "Urban Challenge Technical Evaluation Criteria" documents posted on the event website, www.darpa.mil/grandchallenge.

2. Applicability

This document applies to the selection process for the competitive Urban Challenge autonomous vehicle event.

Information in this document applies to contracted efforts (such as those undertaken by teams on Track A) only as instructed by the DARPA contracting officer. Nothing in this document should be understood or construed to modify the terms of any contract or agreement. Success or failure in meeting milestones in a contracted effort does not determine success or failure in becoming an Urban Challenge semifinalist.

3. Location and Schedule

On the Site Visit Information Sheet (SVIS), teams propose a location within the United States to host the Site Visit. The SVIS is part three of the Urban Challenge Application and is available on the website. The SVIS and the Site Visit Route Network Definition File (RNDF) are due from all teams by the March 16, 2007 deadline, as detailed in Table 1. In addition to the RNDF the team should submit one or more photos of the Site Visit course. These photographs may include diagrams of the course on overhead imagery, and/or ground level shots of the course. A single document should be used for this purpose (.doc, .ppt, .pdf, or .jpg formats acceptable). The maximum file size is 5 MB. DARPA uses the SVIS, the Site Visit RNDF, and the photograph(s) to ensure conformance with the Site Visit guidelines.

Table 1 – Site Visit Schedule

Date	Event	Required Documents
March 16, 2007	Site Visit information due	Site Visit Information Sheet Site Visit RNDF Digital photograph(s) of Site Visit course
April 13	Site Visit information reviews complete DARPA sends notifications	N/A
May 10	Site Visit selection announcement by DARPA	N/A
June 11-July 20	Site Visits at team sites	Original proof of U.S. citizenship Original proof of U.S. residency
August 10	Semifinalist selection announcement	N/A

Teams are notified of their selection for a Site Visit on or before May 10, 2007. For teams selected for Site Visits, DARPA will notify the team leader of a date and time between June 11 and July 20, 2007 for their Site Visit. Scheduling requests may be made when the Site Visit is scheduled, however, DARPA reserves the right to schedule the Site Visit any time during this period. Teams that are unable to accommodate the assigned schedule time forfeit the opportunity to continue in the program. Should DARPA determine a Site Visit needs to be re-scheduled, a date and time will be coordinated with the team leader.

The team is responsible for obtaining all required permits or access rights for their Site Visit location.

Four hours have been allotted for the Site Visit, beginning from the time the DARPA officials meet the team leader at the Site Visit location. All Site Visit activities must take place within this time window.

4. Site Visit Process

4.1. Provisions by the Team

The team leader must be on-site for the duration of the Site Visit. All teams are required to supply the following at the Site Visit location:

1 – Autonomous vehicle
1 – E-stop system (receiver and wireless transmitter)
2 – Traffic vehicles
1 – Control vehicle
1 – Test course meeting the requirements of Section 4
30 – Gate markers (cones, flags or other clearly visible markers are acceptable)
6 – Traffic cones (12” minimum height)
Course marking materials

The autonomous vehicle should be configured to allow a human safety rider in the driver’s seat to override the controls of the autonomous vehicle and take control for safety purposes.

The traffic vehicles may be any drivable full-size vehicle that meets the height, width, weight, and wheelbase requirements of the Urban Challenge Rules (Section 3.2). The control vehicle should be large enough to carry a driver and two passengers, one in the front seat and one in the back seat.

The E-stop equipment supplied by the team for the Site Visit is distinct from the Government-owned E-stop system DARPA will loan to semifinalist teams. The team-supplied E-stop receiver must be installed on the autonomous vehicle and be capable of remote wireless operation via the team-supplied E-stop transmitter by the E-stop operator in the control vehicle.

The team must supply five individuals who will act as the team *test crew*, designated as follows:

1 – Control vehicle driver
1 – E-stop operator
1 – Safety rider
2 – Traffic vehicle drivers

The team may have up to five additional team members as part of the test crew. For purposes of safety, the team is encouraged to keep the size of this group to a minimum. Members of the media may not be part of the test crew.

The control vehicle containing the control vehicle driver and the E-stop operator will follow the autonomous vehicle during the navigation and traffic tests.

4.2. Safety Guidelines

Careful planning is the key to a safe, well-controlled vehicle demonstration and a successful Site Visit. Teams should anticipate possible problems and make appropriate contingency plans. The team must ensure compliance with all Federal, state, and local regulations at the site.

Primary responsibility for safety lies with the team. Concerns regarding any of the Site Visit tests or procedures should be discussed with DARPA before the tests take place, and prior to the Site Visit if possible. Teams may pause or terminate the demonstration at any time should safety issues arise. DARPA may choose to terminate the Site Visit or any part of the Site Visit at any time for any reason.

The team should identify a spectator area with adequate barriers to ensure safe separation of persons and property from the autonomous vehicle. Teams must ensure there is no interference from other vehicles or pedestrian observers during the Site Visit. All individuals who are not members of the test crew (including members of the media, spectators, sponsors, and other team members) must remain within the spectator area.

4.3. Sequence of Events

The team should be organized and prepared to carry out the following steps within the 4 hour Site Visit:

1. *Document Verification.* The team leader must bring to the Site Visit originals of the proof of U.S. citizenship and proof of U.S. residency (Urban Challenge Rules, Section 2.1) for verification by DARPA officials. DARPA officials also collect a liability waiver (available for review on the website) from each team member of the test crew conducting the vehicle demonstration. The liability waiver is signed in front of the DARPA officials at the event. Officials review the objectives and ground rules of the Site Visit. Team members who are not members of the test crew move to the spectator area at this time.

2. *Safety Briefing and Course Inspection.* Team briefs DARPA officials on the course, highlighting any safety or procedural issues. The team conducts a tour of the test course including all required markings. Basic course geometry is verified.

3. *Static Vehicle Inspection.* The team conducts a tour of the vehicle showing in detail the vehicle navigation system, vehicle perception system, onboard processing capability, level of vehicle integration, and provisions for integration of a Government E-stop. The team discusses any variation from the vehicle specifications submitted with their application or proposal. The vehicle is examined for compliance with the vehicle requirements in Section 3.2 of the Urban Challenge rules. Teams demonstrate the procedure the safety rider would follow in an emergency situation.

4. *E-stop Test.* The team demonstrates the ability of the E-stop system to run and pause the vehicle. The team demonstrates the basic pause, disable, and run operation of the E-stop. Using a pre-marked course the team demonstrates that the autonomous vehicle traveling at 20 mph stops safely within 20 meters upon E-stop activation. The vehicle is moved into start position for the first Navigation Run.

5. *Course Preparation.* Navigation Run instructions are provided by DARPA officials. DARPA places the traffic vehicles on the course with the assistance of the team. For these runs, the vehicle will be followed by the control vehicle driven by the control vehicle driver. One DARPA official will ride in the front seat of the control vehicle. The E-stop operator rides in the back seat. Safety riders are not allowed for these tests. To propose an alternative (safer) configuration, teams should contact DARPA at grandchallenge@darpa.mil.

6. *Mission Data File (MDF) Load.* The vehicle is ready for operation within 5 minutes from the time DARPA furnishes a memory stick with an MDF to the team.

7. *Navigation Runs.* DARPA officials observe the runs and record the vehicle's performance. The test crew cooperates with DARPA in configuring the test course for each run.

8. *Traffic Runs.* DARPA officials set up the course and provide the team with MDFs for the Traffic Runs. Traffic Run instructions are provided by the officials, including instructions for the team's traffic vehicle drivers. The safety rider shall ride inside the autonomous vehicle and apply the brakes or take other action should the vehicle's behavior pose an imminent danger to other vehicles, infrastructure or itself. DARPA officials will observe the runs and record the vehicle's performance. To propose an alternative (safer) configuration, teams should contact DARPA at grandchallenge@darpa.mil.

Activities during the Site Visit are focused on vehicle demonstration and testing; filming and other activities should not impede or intrude on the testing process or the DARPA and team officials. Team interviews and vehicle footage should be completed before or after the Site Visit. Teams who anticipate a large number of spectators, members of the media, film crews, or other unusual conditions at the site visit should inform DARPA at least one week prior to the scheduled time. DARPA officials are not available to make comments for the press or to participate in filming at the Site Visit.

5. Route Configuration

5.1. Course Configuration

Figure 1 depicts a typical Site Visit course. The course must contain the minimum set of features described here:

- One 4-way intersection (right-angled) with four stop lines.
- Closed loop course with length between 250 and 500 meters, abutting the intersection and comprising two lanes (lane width less than or equal to 4.5 meters) and 3 right-angle turns in addition to the intersection.
- The minimum distance between any two right angle turns on the closed loop course is 40 meters.
- Two stub roads of minimum length 40 meters abutting the intersection.

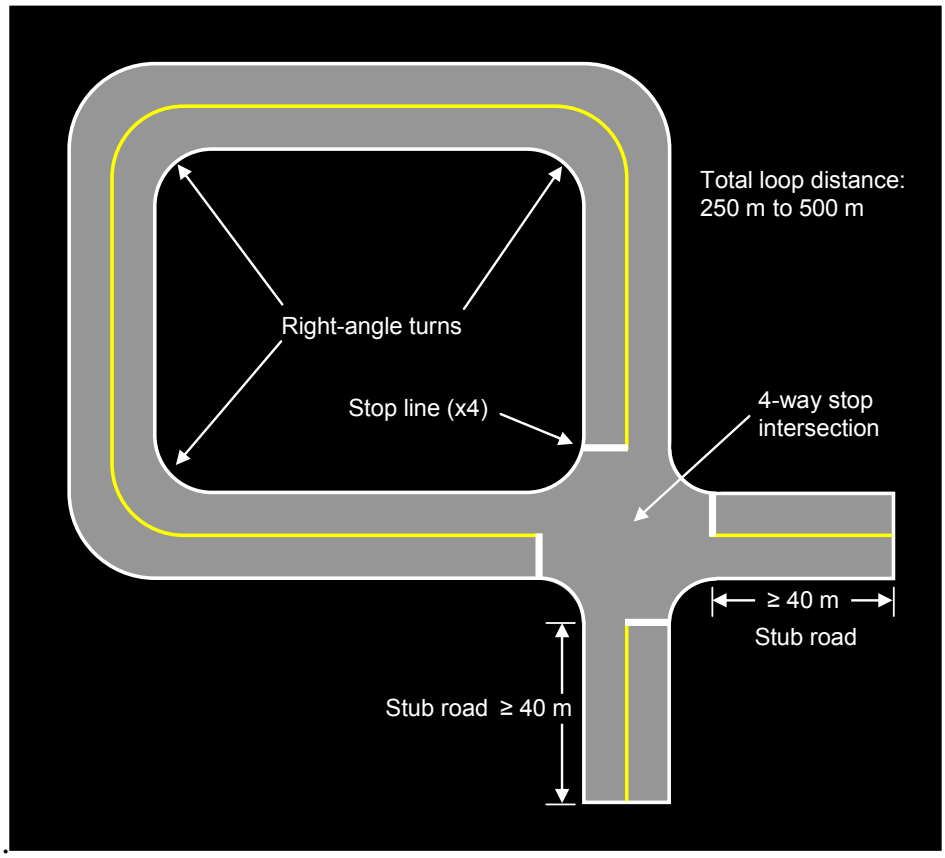

Figure 1 – Site Visit course

The use of paved roads is not required but is strongly preferred. The loop course may curve and wind provided the requisite right-angle turns with required minimum spacing are provided.

For purposes of the site visit, a "right angle turn" is a turn that satisfies the criteria depicted in Figure 2. A point **A** is selected on the centerline of the road near the apex of the turn. A distance of 11 meters is measured to points **B** and **C** lying on the road centerline. The turn qualifies as a "right angle turn" if the straight line distance **BC** is less than or equal to 19 meters.

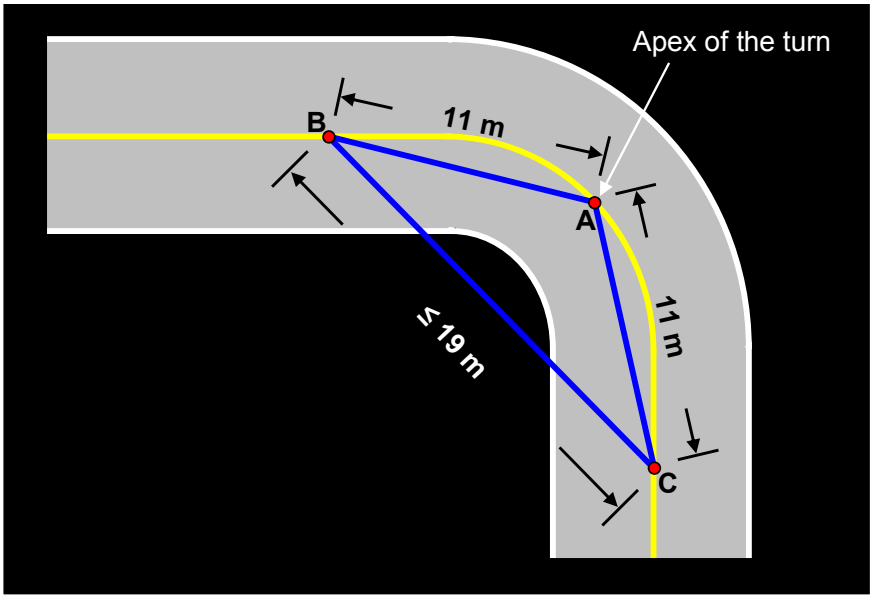

Figure 2 – Right-angle turn measurement

5.2. Route Network Definition File

Teams must submit a Route Network Definition File (RNDF) for the Site Visit course with the SVIS. The RNDF must conform to the format in the "Route Network Definition File and Mission Definition File Formats" document, posted on the event website. The Site Visit course and RNDF must be approved by DARPA for a team to receive a Site Visit.

A sample site visit RNDF is illustrated in Figure 3. The RNDF must meet the following requirements:

a. Test course contains at least two segments, each containing two lanes of equal width.
b. Waypoints are placed around both lanes of the loop road and are located close to lane center. Waypoints should be placed in pairs, one in each travel lane, such that a line segment between them is perpendicular to the direction of travel.
c. The distance between consecutive waypoints in the same lane is between 10 and 25 meters.
d. One exit waypoint is located on the center of each stop line.
e. In each lane leaving the intersection, the waypoint closest to the intersection is an entry waypoint (four locations).

f. Exit and entry waypoints are placed at each end of each lane in each stub road and associated so as to allow a U-turn.
g. Four pairs of checkpoints are located on the loop road, located approximately midway between consecutive right angle turns.
h. One pair of checkpoints is located in each stub road.
i. Each stop line exit waypoint is associated with three entry waypoints (four locations, Figure 4).

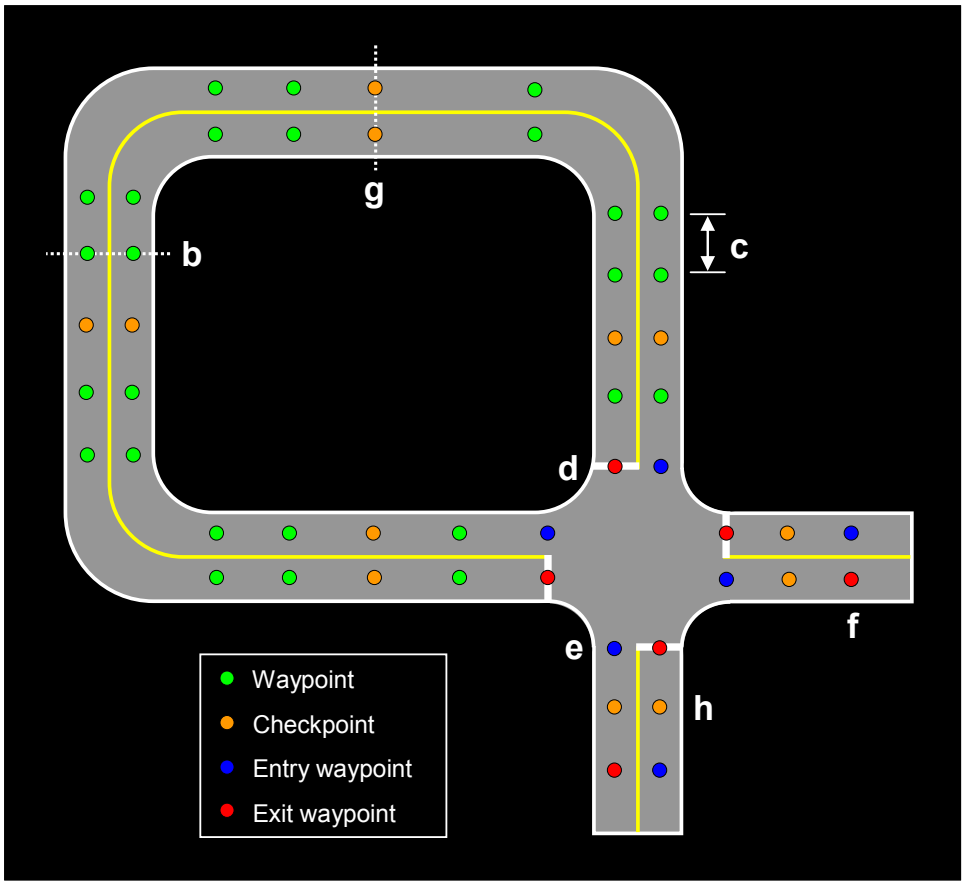

Figure 3 – Sample Site Visit RNDF course illustrating requirements b through h

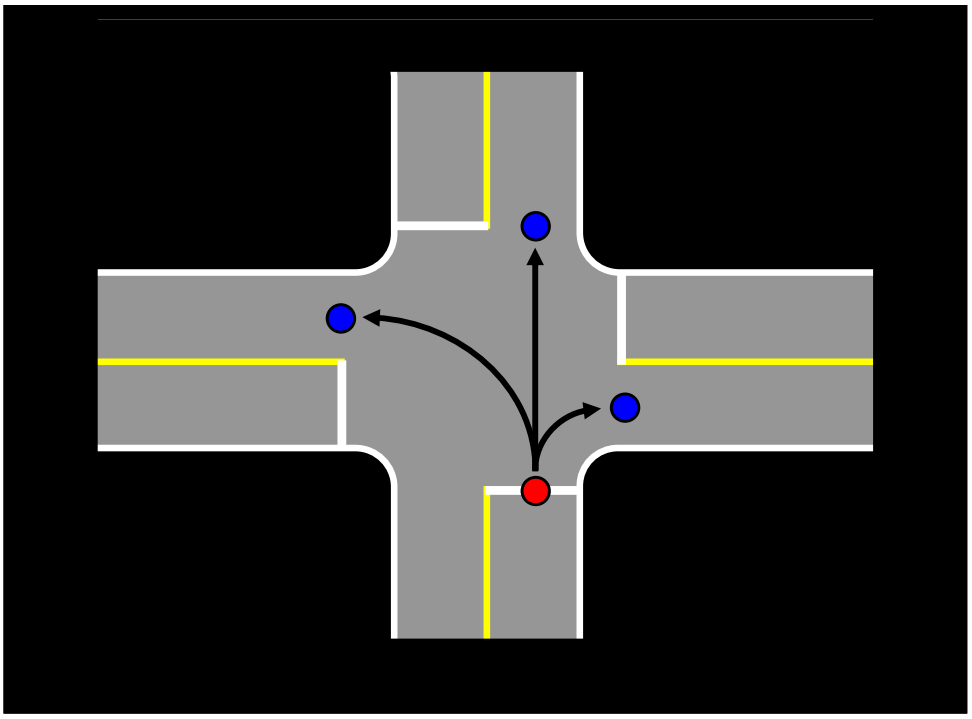

Figure 4 – Exit and entry waypoint associations at the 4-way stop intersection (one of four sets illustrated for clarity)

5.3. Course Marking

The following components of the course must be marked, as shown in Figure 5:

a. *Stop lines.* The four stop lines on the course shall be clearly and visibly marked across the width of the lane.

b. *Waypoints.* All waypoints on the course shall be marked. Chalk, paint, or other equivalent means may be used.

c. *Center line.* The centerline of the segment shall be marked around the entire course. Paint, chalk, or other equivalent means may be used for this purpose. Center lines should not be marked in the 4-way intersection.

d. *Midpoint gates.* Cones or other markers shall be used to define gates by marking the center line and course boundaries at the location of the checkpoint on each of the four legs of the course approximately halfway between the right-angle turns. See Figure 5.

e. *Corner gates.* Cones or other markers shall be used to define gates by marking the center line and course boundaries at locations B and C of each right angle turn as shown in Figure 6.

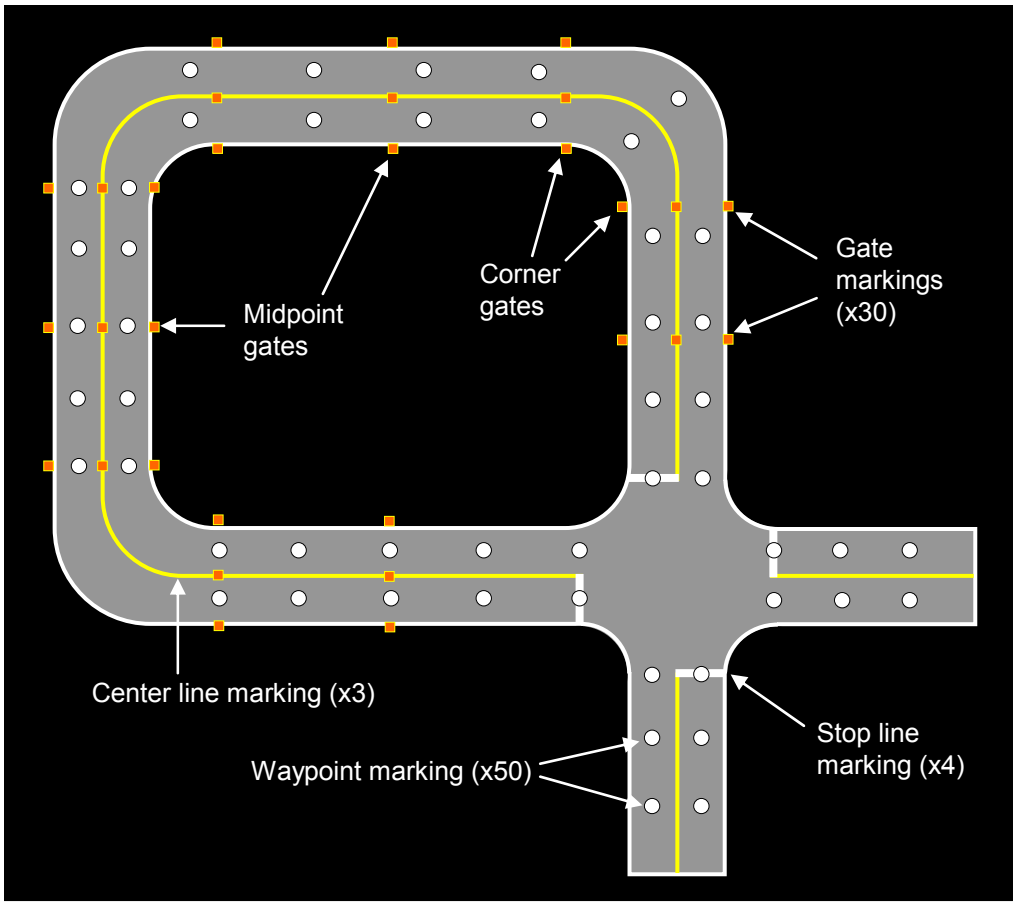

Figure 5 – Course Markings

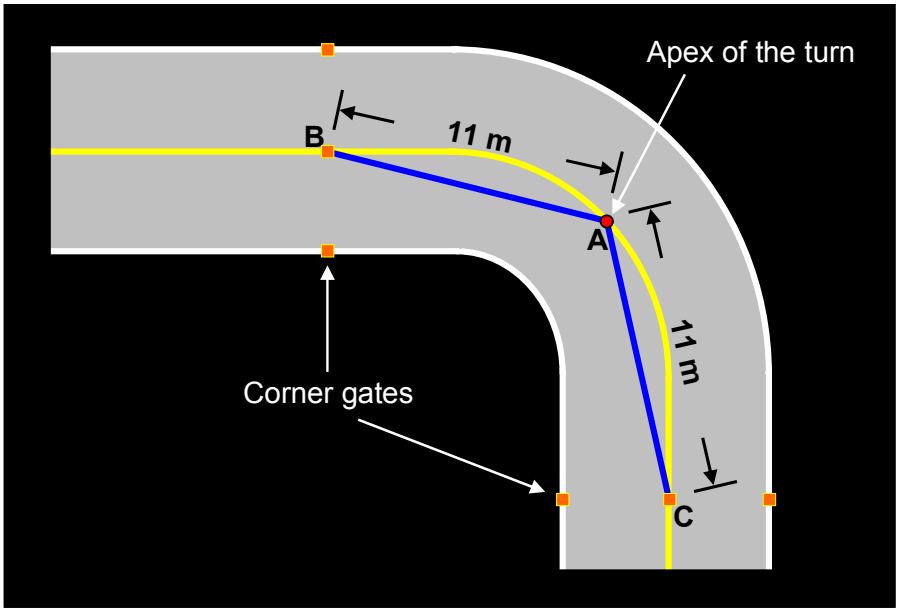

Figure 6 – Corner gate locations

6. Vehicle Behavior

The Site Visit will test vehicle capability against the Basic Navigation and Basic Traffic criteria listed in the "Technical Evaluation Criteria" available on the website. Vehicles must be able to pause and resume in response to E-stop commands at any point during a mission and must be capable of reading and interpreting RNDF and MDF files for the Site Visit.

For the Navigation Runs, the vehicle will be required to follow one or more MDFs and follow the RNDF-defined course while exhibiting Basic Navigation behaviors. The vehicle will not encounter moving traffic during these tests.

For the Traffic Runs, the vehicle must exhibit Basic Navigation and Basic Traffic behaviors as it traverses the course. The vehicle will encounter live traffic during these runs. The vehicle must be able to stop, detect standing and moving vehicles at the four-way intersection, interpret the precedence order correctly, and move through the intersection without violating Technical Criterion A.6 (Excess Delay). For the Traffic Runs at the Site Visit, the autonomous vehicle must never violate the precedence order at the intersection - the vehicle must not exhibit the behavior described in the Technical Criterion D.9 (Traffic Jam) at the Site Visit test. The autonomous vehicle must wait indefinitely until the intersection has cleared and it is the autonomous vehicle's turn to proceed before traveling through the intersection. Once the vehicle has precedence and the intersection has cleared, the vehicle must proceed within 10 seconds.

7. Notification

The team's Site Visit performance will be combined with the Technical Paper evaluation to determine the Urban Challenge semifinalists. Teams will be notified of their selection or non-selection for the NQE by email on or before August 10, 2007.

Individual team scores or rankings will not be released.

Appendix: Site Visit Checklist

Preliminaries

- Email Site Visit Information Sheet to DARPA, including digital photographs(s) of site (March 16)
- Email Site Visit RNDF to DARPA (March 16)
- Receive feedback from DARPA regarding RNDF (April 13)
- Site Visit announcement and invitation (May 11)
- Site Visit scheduling contact from DARPA (May 14-18)

Course

- 250 – 500 meter loop, paved two-lane road
- Right angle, 4-way intersection
- Two stub roads, at least 40m in length
- Lane width less than or equal to 4.5 meters
- 10-25 meters between waypoints
- 40 meters minimum between right angle turns
- Centerline, stop line and waypoint marking
- Mark 4 pairs of midpoint gates and 6 pairs of corner gates
- Verify turns meet the right angle criteria of Figure 2
- Identify area to demonstrate E-stop

On-site

- Citizenship and residency documentation
- Five-person test crew with driver's licenses
- E-stop system and demonstration procedure
- Course markings, to include 30 gate markers and six 12-inch cones
- One control vehicle and two traffic vehicles
- Spectator area with barriers to control and protect spectators
- Autonomous vehicle with RNDF loaded